LIFE LOCAL ADAPT | Integration of climate change adaptation into the work of local authorities

Climate change adaptation activities
Valka municipality

Deliverable to Action C10.2

Due date of deliverable: 31.01.2017
Submission date: xx.xx.xxxx

Project start: 01.07.2016
Duration: 60 months

Version: Draft

CzechGlobe | Das Land Steiermark Erneuerbare Energien und Klimaschutz | GERICS Climate Service Center Germany | LANDESAMT FÜR UMWELT, LANDWIRTSCHAFT UND GEOLOGIE | Freistaat SACHSEN | TECHNISCHE UNIVERSITÄT DRESDEN

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Method selection for adaptation activities

After identifying and evaluating potential risks, next step is to apply the knowledge to identify the practical measures that will allow to succesfully adapt to climate change.

Based on identified national level risks and results of vulnerability assessment, most effective adaptive measures were determined in each of the evaluated fields.

In all of the above areas, the most significant adaptation measures were identified primarily through a qualitative expert approach, based on individual experience in the field as well as the experience of other countries.

1 Adaptation of the biodiversity and ecosystem services to climate change

Based on research findings and expert opinions, a large list of adaptation measures was created, from which the most relevant ones were selected. Selection criteria included factors such as the effectiveness and scale of the measures, labor intensity and financial considerations as well as potential political support.

As a result, the following measures were identified as most significant ones:

1. Development of habitat management program.
2. Development of informational and educational event program.
3. Formation and maintenance of small disperse wetlands in areas dominated by agricultural land.
4. Decreasing the fragmentation and isolation of natural and semi-natural territories by reviewing regulatory enactments and including the requirement for the establishment of green corridors in the framework of spatial planning (for example, TIAN).
5. Creation and naturalization of perennial grasslands in open areas dominated by arable land, thus ensuring the contiguity between biologically valuable grasslands.
6. Mowing of banks/coastal areas of rivers, lakes and seashore (incl. promoting reed economic exploitation).

1.1. Natural habitat management program development

In order to prevent the disappearance of endangered species and to preserve their natural distribution areas, their natural habitats must be protected. Such types of specially protected natural habitats are defined by Council Directive 92/43 / EEK on the conservation of natural habitats and of wild fauna and flora or Habitats Directive.

Table 1. Adaptation measure cost estimate and explanation of the calculation assumption

Measure	Introduction cost, EUR	Implementation cost, EUR	Explanation and source of the calculation assumption
Program development	120 000	120 000	Including work of 50 experts and seminars. *According to the information provided by the experts*
Program implementation		1,2 million	Assuming that the cost of management over a period of 10 years - during the lifetime of the program - amounts to 120,000 EUR per year. Precise calculations are made during program development.

Table 2. Cost effectiveness for measure No.1.1 "Habitat management programs"

[Type text]

Indicator	Value
Capital costs of the event, EUR	-124 080
Full life cycle costs, EUR	-6,98 million
Cost per representative of the target group per year, EUR	0,09

1.2 Informational and educational event program development

Although the adverse impacts of climate change on biodiversity of species are widely documented, some people still have a sceptic attitude towards this topic. Targeted informational campaigns can influence public opinion, promote awareness of the importance of climate change and encourage habitual change in society.

Table 3. Adaptation measure cost estimate and explanation of the calculation assumption

Measure	Introduction cost, EUR	Implementation cost, EUR	Explanation and source of the calculation assumption
Program development	40 000	40 000 (every decade)	The development of the program is expected both during the implementation phase and every 10 years. Costs are calculated based on expert information.
Program implementation		70 000 (per year)	The costs of the implementation of the program are estimated based on the cost of mass communication as well as education and information campaigns in educational institutions.

Table 4. Cost effectiveness for measure No.1.2 “Development of informational and educational event program "for the period from 2017 to 2066”

Indicator	Value
Capital costs of the event, EUR	-40 000
Full life cycle costs, EUR	-2,15 million
Cost per representative of the target group per year, EUR	0,03

1.3 Formation and maintenance of small disperse wetlands in areas dominated by agricultural land.

The diversity of species is rapidly diminishing both through climate change and human activities. One of the important contributing factors is the fragmentation and isolation of habitats. Shrinking to evermore smaller areas that get separated from each other, unfavourable conditions are created within habitats. Species migration and ecosystem interactions are adversely

effected, contributing to inbreeding and endangering the survival of large animals. Changes in the abiotic environment (more sunlight, higher wind speeds) and biota (increased risk of predation and parasitism, entry of other species) can further adversely affect biodiversity. It is therefore necessary to create buffer zones and "ecological networks" to facilitate the movement of animals.

Table 5. Adaptation measure cost estimate and explanation of the calculation assumption

Measure	Introduction cost, EUR	Implementation cost, EUR	Explanation and source of the calculation assumption
Research	85 000		Research costs are calculated taking into account involvement of cartographers, hydrographs and other experts, including the cost of administrative work.
Wetland creation		30 745 000 (gradually over the next 20 years)	Assuming that the wetlands should constitute up 1% of Latvia's total arable land area.

Table 6. Cost effectiveness for measure No.1.3 "Formation and maintenance of small disperse wetlands in areas dominated by agricultural land "for the period from 2017 to 2066

Indicator	Value
Capital costs of the event, EUR	-87 890
Full life cycle costs, EUR	-32,36 million
Cost per representative of the target group per year, EUR	0,41

1.4 Decreasing the fragmentation and isolation of natural and semi-natural territories by reviewing regulatory enactments and including the requirement for the establishment of green corridors in the framework of spatial planning (for example, TIAN).

Additional measures that will reduce the negative impact on biodiversity and facilitate the movement of species include preservation of natural biomes along the water bodies, creation of hedges, and the creation of "Eco duct" - land-based tunnels for animals.

Table 7. Adaptation measure cost estimate and explanation of the calculation assumption

Measure	Introduction cost, EUR	Implementation cost, EUR	Explanation and source of the calculation assumption
Research	75 000		Involvement of experts in natural habitats/ territories, lawyers and administrative work costs.

Connecting and expanding natural territories		117 172 000 (gradually over the next 10 years)	Average cost of creating various natural territories in the base area of 29,562 ha.

Table 8. Cost effectiveness for measure No.1.4 "Decreasing the fragmentation and isolation of natural and semi-natural territories" for the period from 2017 to 2066

Indicator	Value
Capital costs of the event, EUR	-77 550
Full life cycle costs, EUR	-117,25 million
Cost per representative of the target group per year, EUR	1,49

1.5 Creation and naturalization of perennial grasslands in open areas dominated by arable land, thus ensuring the contiguity between biologically valuable grasslands.

Creating grasslands in vast areas of agricultural land would promote the movement of species through the so-called "stepping stones".

Table 9. Adaptation measure cost estimate and explanation of the calculation assumption

Measure	Introduction cost, EUR	Implementation cost, EUR	Explanation and source of the calculation assumption
Research	90 000		Research costs include the work of biology experts, field work, as well as the involvement of lawyers and administrative costs.
		15 668 100 (every year)	State payments to landowners for 248 700 ha area. Accepted single area payment rate offered by LAD (LAD, 2016)

Table 10. Cost effectiveness for measure No.1.5 – "Creation and naturalization of perennial grasslands" for the period from 2017 to 2066

Indicator	Value
Capital costs of the event, EUR	-93 060
Full life cycle costs, EUR	-767,83 million
Cost per representative of the target group per year, EUR	9,76

1.6 Mowing of banks/coastal areas of rivers, lakes and seashore (incl. promoting reed economic exploitation).

As a result of climate change the air temperature as well as the water temperature will increase, which will result in prolonged vegetation and overgrowth of water bodies that need to be limited.

Table 11. Adaptation measure cost estimate and explanation of the calculation assumption

Measure	Introduction cost, EUR	Implementation cost, EUR	Explanation and source of the calculation assumption
Total annual cost for reed mowing		2 847 500 (once a year)	Total annual costs for reed mowing, assuming that 50% of the total reed covered area will be cleared, which is 6,700 ha, provided reed cutting service cost ranges between 350 and 500 EUR (average 425 EUR) per 1 ha. Sources: (LPS, 2016, Chubar , 2014).
Expert conclusion	450 000	450 000 (every 10 years)	*According to the information provided by the expert, estimated expert conclusions cost about the total area of inland waters in Latvia (150 000 ha) Source: (Birzaks, 2013)*

Table 12. Cost effectiveness for measure No.1.6 "Mowing of banks/coastal areas of rivers, lakes and seashore" for the period from 2017 to 2066

Indicator	Value
Capital costs of the event, EUR	-465 300
Full life cycle costs, EUR	-262,11 million.
Cost per representative of the target group per year, EUR	3,34

2 Health and welfare measures in the context of climate change adaptation

Based on research findings and expert opinions, a comprehensive list of adaptation measures was created, from which the most relevant were selected employin multi-criteria methodology.

The multi-criteria approach was based on seven criteria for evaluating events:

- How many of the seven identified risks (the impact of those risks) will be reduced by the measure?

- What is the required amount of public investment (i.e., state, municipality, EU funds) for event/measure implementation?
- What are the expected maintenance costs for the implemented measure?
- Is there any specific preparatory work required for the implementation of the event?
- Would the event/measure, in your opinion, gain support at political level and to what extent?
- Will the event/measure help to solve other acute current problems?
- Would the event/measure have a negative impact on other areas?

As a result, the following measures were identified as most significant:

1. **Introduction of an early warning system** to warn citizens, health and social care institutions about heat waves, including information with recommendations on how to reduce or prevent the adverse effects of heat waves on the health of the population.
2. **Provision of drinking water in public places**. Within the framework of the implementation of this measure, it is planned to determine the number of the available free drinking water points and the cost of introducing additional points.
3. **Informing the public about available air coolers**. For the implementation of this measure, it is necessary to gather information about the various service providers who have already installed the air cooling devices and to display the information in the form of a map on a publicly available information distribution network.
4. Development of legal framework and additional remuneration costs, to provide **additional paid cooling breaks** for employees who work outside during heat waves.
5. **Additional check- ups** of people receiving home care during heat waves. Providing information and educating population on how health is affected by extreme climate factors will help to reduce the adverse effects of those factors as well as encourage timely action in the event of deterioration of health.
6. 6. Implementation of Green Infrastructure projects in densely populated areas for the purpose of temperature regulation, reducing localised overheating effects, etc.

Each of the measures was described and cost-benefit analysis was carried out.

2.1 Introduction of an early warning system to warn about heat waves

Table 13. Costs associated with heat wave early warning systems.

Measure	Introduction cost, EUR	Implementation cost, EUR	Explanation and source of the calculation assumption
Environmental, geological and meteorological expert services	1 322		24 working hours with an industry expert fee of 55.09 EUR / h. *Source: LVĢMC, 2016*
Health expert services costs	1 000	160 (once every 4 years)	The initial recommendation is 50 working hours with an expert fee of 20 EUR / h. 8 expert work hours are planned for reconsideration of recommendations. *According to the information provided by the experts*
PR specialist service costs		4 500 (once every 4 years)	The service provides 150 working hours with a PR specialist with rate of 30 EUR / h. The costs include the production of both video and audio social advertising, and the preparation of social advertising texts for distribution on social networks, as well as communication services. *Source: Expert information on market prices.*
Advertising time on television and radio		20 000 (once every 4 years)	The calculation is based on television advertising costs of EUR 19,000 and an estimated 800 EUR in radio advertising. *Sources: MTG, 2014, LSM, 2016)*
Production of informative posters		13 750 (once every 4 years)	The calculation includes the cost of the poster computer design EUR 25 (provided that PR specialist's services include design costs and 10,000 posters printing costs in the amount of EUR 13750) *Source: SIA, AREATECH, 2016*

10% - the proportion of the target group to be reached by the measure in the total population

Table 14. Cost effectiveness and cost-benefit analysis for the measure No.2.1 – "Heat wave early warning systems" for the period from 2017 to 2066

Indicator	Value
Capital costs of the event, EUR	2
Full life cycle costs, EUR	762
Present value of benefits, thousand, EUR	30 392
incl. life years saved, thousand, EUR	24 792

incl. work years saved, thousand, EUR	5 154
incl. saved productivity costs, thousand, EUR	104
incl. saved health care costs, thousand, EUR	341
Present value of costs, thousand, EUR	401
Cost per representative of the target group per year, EUR	0,07
Benefit - cost ratio	75,80
Net present value, thousand, EUR	29 991

2.2 Providing access to drinking water in public areas

Table 15. Indicative drinking water supply points

Drinking water free access points	Count	Explanation and source
Railway stations	50	It is assumed that free drinking water supply points are installed at railway stations with an average passenger flow of 650 passengers per day, including 20 stations requiring 1 water supply installation (650-2000 passengers per day), 10 stations requiring 2 water access points in each (over 2,000 passengers per day) and Riga central station, which requires 10 water access points to be installed. *Source: Own calculations, LDZ*
Parks and squares	170	It is assumed that free drinking water points are located in public city parks and squares. *Source: official city websites*
Bus station	33	It is assumed that free drinking water points are installed at each bus station with a significant passenger flow. *Source: Lattelecom, Ltd., 2016*
Beaches and swimming pools	56	It is assumed that the largest flows of people are choosing official swimming areas. *Source: Health Inspectorate, 2016.*
Total	**309**	

Table 16. Adaptation measure cost estimate and explanation of the calculation assumption

Measure	Introduction cost, EUR	Implementation cost, EUR	Explanation and source of the calculation assumption
Establishment of a connection to the city water main	1,55 million		The cost was calculated taking into account the cost of connection creation in approx. 309 places - 5000 EUR, assuming that the distance of the chosen location to the city water main is not more than 50 m. *Source: expert estimates.*
Water Purifiers - Filters	43 260	43 260 (once a year)	A water purification filter for each connection is installed at the time of implementation and repeated every year. *Source: SIA Golan Group, 2016*
Maintenance of water extraction sites		92 700	Maintenance costs for water supply are calculated on the assumption that the maintenance of one place for 6 months is EUR 50 per month. *Source: Expert estimates of average costs.*

30% - the proportion of the target group to be reached by the measure in the total population

Table 17. Cost effectiveness and cost-benefit analysis for the measure No.2.2 – "Providing access to drinking water in public areas" for the period from 2017 to 2066

Indicator	Value
Capital costs of the event, EUR	1 625
Full life cycle costs, EUR	13 536
Present value of benefits, thousand, EUR	54 207
incl. life years saved, thousand, EUR	44 238
incl. work years saved, thousand, EUR	9 206
incl. saved productivity costs, thousand, EUR	178
incl. saved health care costs, thousand, EUR	585
Present value of costs, thousand, EUR	7 628
Cost per representative of the target group per year, EUR	0,45
Benefit - cost ratio	7,11
Net present value, thousand, EUR	46 579

2.3 Providing information on cooling options

Table 18. Costs related to the establishment of an inventory system for available air cooler systems.

Measure	Introduction cost, EUR	Implementation cost, EUR	Explanation and source of the calculation assumption
Research - and the attraction of cooperation partners	1,95 million	654 965 (every decade)	The cost of attracting initial research and collaboration partners is calculated on the assumption that on average for every 300 inhabitants there is one institution of interest, whose clearance, inspection, contract creation and registration would cost an average of 300 euros. Recurring costs are calculated on the assumption that some of the partners will renew the same contract, with the average cost of including and inspecting one building at EUR 100. Prediction includes that the number of inhabitants and the number of public buildings will decrease.
Leaflet production		14 875 (once every 4 years)	The cost of leaflets includes the average production of 500 leaflets for each municipality with a printing fee of EUR 125. The content of leaflets is part of a local government responsibility and is not included in the cost. *Source: AREATECH, Ltd., 2016*
Map printing	7 000 (after initial research)	7 000 (every decade)	Following the study and the contracts resulting information will be presented in a map format for each municipality. It is planned to make one map for each of the municipalities of the regions, and an average of 50 maps each for the cities of the republic. The print costs for each map are EUR 12.50, and card designed is part of the study. *Source: AREATECH, Ltd.,2016*
Creation and maintenance of the mobile application	8 000	2 000 (every decade)	The initial application creation will include 160 programmer working hours at a rate of 50 EUR / h, while 40 working hours are predicted requirement for application improvement.

10% - the proportion of the target group to be reached by the measure in the total population

Table 19. Cost effectiveness and cost-benefit analysis for the measure No.2.3 "Providing information on cooling options" for the period from 2017 to 2066

Indicator	Value
Capital costs of the event, EUR	2 047
Full life cycle costs, EUR	6 095
Present value of benefits, thousand, EUR	13 270
incl. life years saved, thousand, EUR	10 833
incl. work years saved, thousand, EUR	2 254
incl. saved productivity costs, thousand, EUR	43
incl. saved health care costs, thousand, EUR	142
Present value of costs, thousand, EUR	4 144
Cost per representative of the target group per year, EUR	0,52
Benefit - cost ratio	3,20
Net present value, thousand, EUR	9 127

2.4 Evaluation / development of a regulatory framework for reduced workload in case of elevated temperatures

Table 10. Adaptation measure cost estimate and explanation of the calculation assumption

Measure	Introduction cost, EUR	Implementation cost, EUR	Explanation and source of the calculation assumption
Development of legal framework			The development of a legal framework is foreseen in the day-to-day management of public administration and therefore its costs are not counted.
Remuneration costs for additional paid working hours		7,07 million (every 4 years)	The total cost is calculated by adopting a model that outdoor workers (154,000) during heat wave days (9 days every 4 years) will create additional costs of 1 hour per day due to additional paid breaks (average hourly rate of 5.11 EUR). *Source: CSB*

8% - the proportion of the target group to be reached by the measure in the total population

Table 21. Cost effectiveness and cost-benefit analysis for the measure No.2.4 "Development and implementation of a regulatory framework for workload during heat waves" for the period from 2017 to 2066

Indicator	Value
Capital costs of the event, EUR	0
Full life cycle costs, EUR	175 451
Present value of benefits, thousand, EUR	18 417
incl. life years saved, thousand, EUR	15 027
incl. work years saved, thousand, EUR	3 126
incl. saved productivity costs, thousand, EUR	61
incl. saved health care costs, thousand, EUR	202
Present value of costs, thousand, EUR	89 355
Cost per representative of the target group per year, EUR	21,04
Benefit - cost ratio	0,21
Net present value, thousand, EUR	-70 938

2.5 Measures for monitoring older people and people with disabilities during heat waves

Additional check-ups might be required for elderly people and people with disabilities who receive care at home.

Table 22. Adaptation measure cost estimate and explanation of the calculation assumption

Measure	Introduction cost, EUR	Implementation cost, EUR	Explanation and source of the calculation assumption
Development of an additional check-up plan			The development of an additional check-up plan is included in the framework of the day-to-day running of public administration and local government authorities, and therefore its costs are not counted.
Additional home visits to the target group		1,39 million (every 4 years)	The cost is calculated, taking into account that each recipient of the home care home (13 856, LM) receives an additional one-hour visit on each day of the heat wave and one visit after the heat wave. The hourly rate for a care provider is estimated at EUR 10, increasing the work rates of the current industry workers, as well as the desired increase. *Sources: Samaritan Association, CSB, own calculations.*

1% - proportion of target group reached by the measure

Table 23. Cost effectiveness and cost-benefit analysis for the measure No.2.5 "Ensuring additional home care during heat waves" for the period from 2017 to 2066

Indicator	Value
Capital costs of the event, EUR	0
Full life cycle costs, EUR	12 386
Present value of benefits, thousand, EUR	1 568
incl. life years saved, thousand, EUR	1 279
incl. work years saved, thousand, EUR	267
incl. saved productivity costs, thousand, EUR	5
incl. saved health care costs, thousand, EUR	17
Present value of costs, thousand, EUR	6 421
Cost per representative of the target group per year, EUR	11,59
Benefit - cost ratio	0,24
Net present value, thousand, EUR	- 4 854

2.6 Implementation of Green Infrastructure projects in urban and densely populated areas

Table 24. Adaptation measure cost estimate and explanation of the calculation assumption

Measure	Introduction cost, EUR	Implementation cost, EUR	Explanation and source of the calculation assumption
Park creation costs	179 million		Park construction costs are calculated on the assumption that created parks will contain a sufficient number of trees to provide shading for the area, as well as a moderate amount of benches and pavement. The amount is calculated for 1.79 km^2, which is a required increase for the existing green city areas of the republic, at a cost of EUR 100 per 1 sq. M. *Sources: Urban development plans, expert information*
Park maintenance costs		38,09 million	Park maintenance costs are calculated on the basis of an average management fee per m^2 managed per year (EUR 20). *Source: Expert information*

50% - the proportion of the target group to be reached by the measure in the total population

Table 25. Cost effectiveness and cost-benefit analysis for the measure No.2.6 "Green infrastructure implementation in urban and densely populated areas" for the period from 2017 to 2066

Indicator	Value
Capital costs of the event, EUR	179 000
Full life cycle costs, EUR	3 411 813
Present value of benefits, thousand, EUR	4 365
incl. life years saved, thousand, EUR	3 547
incl. work years saved, thousand, EUR	728
incl. saved productivity costs, thousand, EUR	22
incl. saved health care costs, thousand, EUR	68
Present value of costs, thousand, EUR	1 792 331
Cost per representative of the target group per year, EUR	67,83
Benefit - cost ratio	0,0024
Net present value, thousand, EUR	-1 787 966

3 Adaptation of landscape management and tourism to climate change

To reduce the impact of adverse climate change in the future and to promote landscape planning and tourism development, the following measures were identified:

- Tourism planning, territorial development, including landscape planning and nature conservation planning;
- Exploration of landscapes in the context of climate change and a climate-sensitive landscape-significant areas and viewing sites, incl. ones that are essential for tourism, maintenance of such territories, management and conservation measures, etc .;
- Landscaping of harmonious green infrastructure in permitted locations to minimize flood, sea flooding, negative effects of marine erosion risks;
- Building dams and protective structures as a scenic viewpoint (where applicable);
- Coastal reinforcement, anti-erosion measures;
- Adaptation of the tourist infrastructure for the winter season (snow cannons, cooling in summer season);
- Construction of active recreational and sports facilities (ice skating, swimming pools, stadiums) as an alternative or in addition to outdoor activities, and other events.

4 Adaptation of the agricultural and forestry area to climate change

The study identified 5 potential agricultural measures and 13 forestry measures that could reduce the impact of adverse climatic changes in these areas.

4.1 Measures identified in agriculture:

4.1.1 Crop diversification

Crop diversification can contribute to adaptation to climate change in several ways:

- the prevalence of pathogenic organisms will slow down and the possibility of rapid proliferation decreases;

- partial loss of crop yields due to inappropriate weather conditions does not significantly reduce the total crop production level;

- a reasonable plant change is encouraged, therefore reducing soil degradation risk.

In order for this measure to be successfully put into practice, farmers must be educated about the potential benefits of diversifying crops.

4.1.2 Maintenance and restoration of the drainage system

Taking into account that under current climatic conditions in Latvia the annual precipitation level exceeds total evaporation amount, the regulation of moisture prevents its accumulation and avails the use of agricultural land.

In accordance with the Land Reclamation Act (in force since 25.01.2010), land reclamation is a land improvement that reduces the adverse effects of climatic conditions and ensures the sustainable use of natural resources.

4.1.3 Implementation of climate change tolerant breeds and implementation of appropriate technological measures

Local breeding work and testing of introduced varieties should be intensified. Educational campaigns should be implemented, informing farmers about the characteristics of the breeds, their potential benefits and the specific characteristics of their cultivation in Latvian conditions. The breeding path can provide a robust cultivar with increased tolerance to biotic and abiotic stresses, such as diseases and pests, drought, frost, and moles.

4.1.4 Monitoring the spread of organisms harmful for crops and animals, and introducing integrated plant protection management system

Effective control techniques and tools are required to prevent or reduce the impact of harmful organisms (i.e. pathogens, weeds and pests) on local crops and animals. To achieve this goal:

1) Further studies must be conducted on the distribution of crop and animal pests and control possibilities;

2) The introduction of more effective integrated pest management system should be promoted;

3) Educational campaigns should be organised, informing farmers on the potential benefits of integrated farming.

In accordance with the Law on Plant Protection (in force since 13 January 1999), State Plant Protection Service, which is a direct administration institution subordinate to the Ministry of Agriculture, organizes and carries out state supervision in the field of plant protection. The State Plant Protection Service (VAAD), having attracted financial resources from the European Agricultural Fund for Rural Development, has prepared a website "Integrated Plant Growing and Monitoring of Harmful Organisms", as well as published informative materials on Integrated Plant Production.

4.1.5 Insurance.

At present, the agricultural risk insurance system is managed by the private sector, creating a huge financial burden for farmers, especially for small farms. State aid is available to cover partial cost of acquiring insurance policy, but the existing insurance system needs to be improved.

4.2 Forestry measures (in priority order):

4.2.1 Young forest care

From adaptation point of view (tree stability to wind damage), it is essential that young forest is cared for when the tree height reaches 4-6m. Considering the increased risk fungal-caused wood decay, which reduces the value of wood and the resistance to other damage (winds, dendrophobic insects), it is important to set up a stable plantation and monitor tree development to choosing the optimum time for the fall.

The measure is supported by the Rural Development Program (LAP), for new forest creation by planting seeds or seedlings, as well as the Forest and Related Sector Development Guidelines (MSNP).

4.2.2 Creation of lower floor thickness plantations

The creation of lower-density plantations with the use of bred and morphologically and physiologically-qualitative seedlings.

4.2.3 Selected planting material for forest renewal

MSNP mentions forest regeneration without a specific funding source.

4.2.4 Selection of planting material for forest cultivation

The LAP provides support for the afforestation of non-productive agricultural land. From the point of view of adaptation, support would be more important for the direct planting of plantation forests, whose initial density is lower - hence the individual stability - higher.

4.2.5 Diversifying plants at plantation, forest or property level

Mixing or species diversification can have a significant positive effect, for example, in areas with a higher risk of fungal root damage (by reducing the contact between tree roots of affected tree species); however, it can also have a negative effect - increasing wind damage in coniferous trees. In order to maximize the impact on adaptation, more detailed aid conditions are required.

The LAP provides support for the development of a diversified afforestation on low-yield agricultural land (also referred to as MNSP) and thinning, granting a higher financial aid for latter.

4.2.6 Extension of the forest network

LPA indicated the requirement for the action; MNSP provides more details regarding possible resources.

4.2.7 Construction of forest drainage systems;

Land reclamation systems have an impact not only on the vitality of the trees, hence their resistance to the effects of biotic factors, but also on the aeration and properties of the soil, hence the depth of tree roots, anchoring in the soil, which affects their resistance to wind damage.

RDP and MNSP support the reconstruction of existing systems, but not new system introduction.

4.2.8 Use of the delivery technology with lowering pressure on the soil

4.2.9 Forest fertilization

Potentially significant direct positive effect (reducing the impact of pests on spruce stands on peat soils and promoting their vitality after damage) and intermediate positive effect (promoting tree growth) and enhanced adaptation, however, the implementation requires nuanced recommendations.

4.2.10 Selective logging use in forestry

In the short run, selective forest clearing reduces the resistance of the trees to damage, and a similar effect is also expected in the sample logging. It is possible that such situation might be favourable for certain species, however, no long term research has been conducted in Latvia in order to be able to design detailed recommendations.

4.2.11 Maintenance of forest pest and disease monitoring

LAP support the installation of monitoring equipment for forest fire, pest and disease monitoring and communications equipment; MSNP is defined more precisely - maintenance of

monitoring equipment from the state budget funds. Programs provide resources for monitoring, but do not provide support for monitoring data use.

4.2.12 Wider use of European tree species, which distribution range includes northern border of Latvia

4.2.13 Wider use of available tree species introduced in Europe.

Table 26. Assessment of forestry adaptation measures.

Measure No.	Measure rating according to indicators					
	Technical	Budget	Organise	Amplify	Included	Known
1	9	9	10	8	in part	10
2	10	10	10	8	no	7
3	10	10	9	8	in part	10
4	10	10	7	8	in part	10
5	8	8	7	6	in part	3
6	6	2	9	10	included	10
7	6	2	2	7	no	9
8	10	6	8	6	no	9
9	7	8	6	8	no	6
10	6	5	5	6	in part	5
11	9	10	10	7	included	10
12	6	6	7	6	no	6
13	6	6	5	6	no	6

The criteria used in the project method are:

Technical - how easy is technical implementation of the measure (ranging from 1 to 10, the expert method, 10 always the highest / "most positive" rating).

Budget - what is the suitability of the cost of a measure with budget opportunities (grading from 1 to 10, expert method).

Organize - how easy the event can be implemented in an organizational manner (it will not have resistance from members of involved parties) - (grading from 1 to 10, expert method).

Amplify - what is the multiplicative effect of the event, positive synergy with other problem-solving options (grading from 1 to 10, expert method).

Included - To what extent measure is included in the existing policy documents (included – fully included) or in part – clarifications are required (see description of the measures); no - not included (for individual measures see also the description).

Known - to what extent the existing knowledge base is sufficient for recommendations (grading from 1 to 10, expert method).

Table 27. Cost effectiveness and cost-benefit analysis for the climate change adaptation measures in agricultural and forestry.

Measure	Net present value for a 50 year period at a discount rate of 2.6%, based on the standardized excel calculation	Cost-benefit ratio	Technical event implementation probability	Measure cost concurrence with budgetary allowance	Organisational possibility of event	Multiplicative effect of the event, positive synergy with other problem-solving options
Agricultural measures						
Monitoring the spread of crops and animal pests and introducing integrated plant protection	9 347 573	2213.72	7	9	9	8
Insurance	186 485	2.68	9	7	7	7
Forestry measures						
Young forest care at a height of 4-6 m to a lower density	113 005 792	15.21	9	9	10	8
The creation of lower-density	137 998 491	31.90	10	10	10	8

plantations with the use of bred and morphologically and physiologically-qualitative seedlings						
Selected planting material for forest renewal with seeds or seedlings	31 579 579	2.43	10	10	9	8

5 Adaptation of construction and infrastructure to climate change

To reduce risk and vulnerability, adaptation measures were reviewed in four categories:

- Necessary changes to legislation and planning documents;

- Additional studies required to clarify the impact;

- Practical measures in addition to those already planned;

- Specific support measures (informative, financial support, etc.).

5.1 Construction

Table 28. Socio-economic gain indicators of measure/event plan

Measure	Investment amount, million, EUR	Investment economic present Net value (ENPV), million, EUR	Investment economic benefits - cost ratio
Rain drainage and sewer system improvement up to required level	30	-0,1	0,97
The use of green infrastructures in the urban environment as an alternative to rain flood water storage	10	2,7	1,56
Natural shade solutions for buildings to reduce the cost of installation and use of air conditioning systems	10	2	1,87

5.2 Energy sector

Based on the VARAM report on adaptation measures prepared for the EC, the currently planned adjustment measures for the energy sector are listed in Table 29.

Table 19. Adaptation measures in the energy sector

Planned political measures/initiatives /(P)	Responsible/Involved institutions	Financing / financial resources / mechanisms [84]
- Construction law - Building standards based on and construction climatology - Methodological guidance for determining the effects of wind - Law on Environmental Impact Assessment - Revision of the Construction Code (P) - National Reform Program "EU 2020" for implementation of the strategy - Reconstruction of HES, strengthening of river bearing - Providing portable electric generators for local areas and public administrative buildings - Energy Law - National Security Law - Long-term national plan for the development of the Baltic Sea coastal public infrastructure - Review of Critical Infrastructure Laws (P) - Review of legislation and policy planning documents on adaptation to the climate change monitoring system (P)	- Ministry of Economics - Ministry of Environmental Protection and Regional Development - Ministry of Agriculture - Latvian Builders Association - Civil Engineers Organization - Ministry of Transport - Road administration - Latvian Chamber of Commerce and Industry - Riga Technical University - Latvian Environment, Geology and Meteorology Center (LVĢMC) - Latvian Association of Local and Regional Governments - AS "Latvenergo" - AS " Distribution Network " - Regional planning - Municipalities	- State budget - Local government budget - Companies - EU funds - Insurance - Latvenergo AS - *Financial Instrument for Climate Change* - *Latvian Environment protection fund*

Table 30. Socio-economic gain indicators of measure/event plan

Measure	Investment amount, million, EUR	Investment economic present Net value (ENPV), million, EUR	Investment economic benefits - cost ratio
Power line cleaning and cabling	0,0	48,411	0,161

5.3 Transport

In order to adapt roads to climate change, following national-significance level events were identified:

1.1. In case of flood danger:

- Prepare drainage systems (cleaning or resizing);
- Thicker drainage layer;
- lifting of roads;
- gravel road asphalt as a primary long-term solution, as well as gravel delivery and grading;
- improvement of asphalt pavement material (polymer-enriched bitumen);
- insertion of reinforcement bars (can have negative aspects related to freeze-thaw cycles);
- using vegetation as a barrier (also for snow).

1.2 Risk of storms - on roads that cross forests - the expansion of the cleared band.

1.3 Risk of road melting - improvement of asphalt pavement material.

1.4 Prioritizing roads that require improvements to provide alternative access and, consequently, significantly reduce potential negative impacts in rural areas.

EU funding support for the development and reconstruction of transport infrastructures will end in 2020.

During road design process, it is advisable to develop guidelines for changes in rainwater runoff as well as support and inspection mechanisms for ports in order to reduce the impact of climate change driven flooding of the sea.

6 Adaptation to climate change in the field of civil protection and emergency assistance

In order to facilitate the adaptability of the system and to reduce vulnerability to the risks of climate change in the field of civil protection and emergency assistance, five potential measures were identified:

1. **Creation of a unified database on disaster losses.**
2. **Early warning.**
3. **Improving the prediction system.**
4. **Territorial planning and related legislation review.**
5. **Civil Safety training course.**

Disaster management includes three types of activities - preventive actions, emergency planning and management (response) and post-disaster assistance. The goal was that adaptation measures would cover all of these three aspects.

Table 31. Climate change adaptation measures in the field of civil protection and emergency assistance.

No.	Adaptation measures	Prevention	Emergency situations planning and management	Post disaster aid and insurance
1	Creation of a unified database on disaster losses		X	X
2	Early warning		X	
3	Improving the monitoring and prediction system	X	X	
4	Territorial planning and related legislation adaptation	X		
5	Education (planned civil safety course)	X	X	

6.1 Creation of a unified database on disaster losses

The development and implementation of a unified database will allow to reduce data collection time, facilitate calculation of losses, and lead to a more effective decision-making.

Table 32. Adaptation measure cost estimate and explanation of the calculation assumption

Measure	Introduction cost, EUR	Maintenance cost, EUR (periodicity)	Explanation and source of the calculation assumption
1.Research	40 000,00	-	Information provided by experts
2.Research	-	-	Under responsibility of dedicated authorities, within their competence level
Unified database creation and implementation	65 070,97	-	Purchasing RAIM System Development 191 Given the complexity of the RAIM system, the cost of developing a single disaster loss database is estimated at 1/5 of the RAIM system costs.
Creation of informative materials for database users	4 000,00	-	Information provided by experts
Providing information and training to local government representatives and other involved entrepreneurs	-	-	Provided by the VUGD, no additional cost.
Database maintenance	-	-	Provided by the Ministry of the Interior information center within the existing capacity.
Implementation of add-ons	-	9 230,00	Information provided by experts

Table 33. Cost effectiveness for the measure "Creation of a unified database on disaster losses"

Indicator	Value
Capital costs of the event, EUR	115
Full life cycle costs, EUR	198
Present value of benefits, thousand, EUR	-
Present value of costs, thousand, EUR	156
Benefit - cost ratio	n/a
Net present value, thousand, EUR	-156

6.2 Early Warning

According to a survey carried out by VUGD and SKDS [1], currently available 164 sirens and alert system could reach up to 37% of the country's population. An effective warning system requires at least double the number of people reached. This can be achieved by doubling the number of warning sirens (refer to the table) or by introducing a cell broadcast system for early warning.

Table 34. Adaptation measure cost estimate and explanation of the calculation assumption

Measure	Introduction cost, EUR	Maintenance cost, EUR (periodicity)	Explanation and source of the calculation assumption
1st alternative: Increase the number of alarms			
Purchase and setting up of alarms (164 pieces)	7 095 294,69	-	43 263,99 EUR x 164 pieces
Maintenance cost	-	118 369,14 (every year)	Maintenance costs for existing sirens x 2; Presentation of the evaluation of the effectiveness of the civil alert and alert system; information provided by experts
2.nd alternative: Early warning systems based on a cell broadcast system			
Notification and management systems creation (AVS)	736 920,00	-	Information provided by experts
Cell Broadcasting Center (ŠAC) infrastructure for 2G, 3G, 4G and 5G cell network connectivity	1 375 584,00	-	Information provided by experts
Cell broadcasting cells activation in 2G, 3G, 4G and 5G network	2 407 272,00	-	Information provided by experts
Annual maintenance services	-	393 024,00 (every year)	Information provided by experts
Maintenance of the existing alert siren system	-	59 184,57 (every year)	Presentation of the effectiveness of the civil alert and notification system; information provided by experts

Table 35. Cost effectiveness for the measure "Early Warning"

Indicator	Value
Capital costs of the event, EUR	4 520
Full life cycle costs, EUR	27 130
Present value of benefits, thousand, EUR	2 543
Present value of costs, thousand, EUR	17 255
Benefit - cost ratio	0,15
Net present value, thousand, EUR	-14 713

6.3 Improvement of forecasting system.

Improvement of disaster forecasting systems and connecting them with the existing warning and monitoring system would enable more effective forecasting, timely preparation and response to potential disasters, and plan for the resource requirements for adaptation and mitigation of consequences.

Table 36. Adaptation measure cost estimate and explanation of the calculation assumption

Measure	Introduction cost, EUR	Maintenance cost, EUR (periodicity)	Explanation and source of the calculation assumption
Creation of an operational atmosphere modelling system	2017= 200 000 2018= 200 000 2019= 200 000 total 600 000	50 000 (once every 6 years)	Information provided by experts
Creation of an operational flood system	2017= 200 000 2018= 200 000 2019= 200 000 total 600 000	50 000 (once every 6 years)	Information provided by experts
System interconnection	80 000	-	Information provided by experts
Linking with the alert system	80 000	-	Information provided by experts
Adaptation of the monitoring system	100 000	-	Information provided by experts

Table 37. Cost effectiveness for the measure "Improvement of forecasting and monitoring system"

Indicator	Value

Capital costs of the event, EUR	1 460
Full life cycle costs, EUR	2 360
Present value of benefits, thousand, EUR	-
Present value of costs, thousand, EUR	1 874
Benefit - cost ratio	n/a
Net present value, thousand, EUR	-1 874

6.4 Territorial planning and related legislation review.

Measure includes a review of construction constraints and recommendation adjustment in the light of future climate change. Legislative restrictions on the construction in the spring flood, sea flooding and rainfall-caused flooding affected areas need to be established. Additionally, existing flood risks territories must be assessed and implementation of preventive measures must be considered.

Table 38. Adaptation measure cost estimate and explanation of the calculation assumption

Measure	Introduction cost, EUR	Maintenance cost, EUR (periodicity)	Explanation and source of the calculation assumption
Development of the initial assessment of the normative act	100 000	-	Estimation provided by experts
Legislative changes, implementation	-	-	Included within the framework of the day-to-day running of public administration, hence costs are not counted.
Identification of climate change, forecasting / updating	-	-	Included within framework of the work of the LVĢMC, hence its costs are not to be considered.

Table 39. Cost effectiveness for the measure "Territorial planning and related legislation review"

Indicator	Value
Capital costs of the event, EUR	100
Full life cycle costs, EUR	100
Present value of benefits, thousand, EUR	2 591
Present value of costs, thousand, EUR	100
Benefit - cost ratio	25,91
Net present value, thousand, EUR	2 491

6.5 Civil Safety training course.

The Ministry of Education commenced work on the development of the contents of the civil safety training course, the implementation of which is scheduled for 2018-2019.school year. The course also provides training on the consequences of climate change and the impact on security risks.

Table 40. Adaptation measure cost estimate and explanation of the calculation assumption

Measure	Introduction cost, EUR	Maintenance cost, EUR (periodicity)	Explanation and source of the calculation assumption
A digital test of pupils' knowledge and skills on civil safety issues was conducted in four age groups	9 750,00		VISC publication, expert information
Development of the course content and program sample	18 100,00		VISC publication, expert information
The development of a teacher's professional full-time program, preparation of multipliers, implementation of the professional development program (1628 general education schools and 102 trade school teachers, 70 training groups for 25 people), administrative and economic services	2017= 75 300,00 2018= 50 200,00 total 125 500,00		VISC publication, expert information
Pilot project in 10 educational establishments for the appropriateness of curriculum content in order to obtain detailed, reliable data on the content of the training and to improve it.	37 100,00		VISC publication, expert information
Textbooks in electronic and paper format and development of teaching and methodological materials on topical issues of civil security.	2017= 83 750,00 2018= 167 500,00 2019= 83 750,00 total 335 000,00		VISC publication, expert information
Events to highlight civil safety relevance, popularization of good practices of teachers (regional events)		2017= 7 600,00 2018= 5 000,00 2019= 2 500,00 total 15 100,00	VISC publication, expert information

Table 41. Cost effectiveness for the measure "Education – civil safety training course ".

Indicator	Value
Capital costs of the event, EUR	525
Full life cycle costs, EUR	541
Present value of benefits, thousand, EUR	-
Present value of costs, thousand, EUR	530
Benefit - cost ratio	n/a
Net present value, thousand, EUR	-530

Summary of nationally identified adaption activities

Based on previously identified risks of climate change, strategies were developed in order to mitigate the negative impact and facilitate adaptation to the new conditions.

Extensive list of propositions was created by a team of experts in their respective fields using brainstorming method. It was further narrowed down to the most relevant adaptation activities based on predicted effectiveness, spectrum of action, implementation cost and effort required, as well as political support probability.

Following key activities were chosen:

Biodiversity and ecosystem services

- Establishing a natural habitat protection plan;
- Development of educational plan for general population;
- Creation of small, disperse wetlands and grassy surface isles in extensively farmed lands ;
- Prevention of wildlife population fragmentation and isolation by creating “green corridors”;
- Mowing of sea, lake, river banks to prevent eutrophication, and preserve biodiversity.

Health and welfare

- Early warning system implementation;
- Ensuring drinking water access in public places;
- Informing population about accessible cooling devices;
- Developing a legislative strategy to ensure additional cooling breaks;
- Offering additional health checks during heat waves for home-care patients;
- Developing shady green areas in densely populated areas.

Landscape planning and tourism

- Landscape and tourism planning to mitigate negative effects of climate change;
- Preventing shoreline erosion;
- Offering indoor activities and events (swimming pools, stadiums, ice skating venues).

Agriculture and forestry

- Diversifying crops, development of crop varieties with increased tolerance to climate changes;
- Land reclamation system maintenance and upgrade;
- Invasive plant and pest control in agriculture and forestry;
- Developing tailored farm insurance policies;

[Type text]

- Coppice maintenance;
- Employing plant breeding technologies to create seedlings for forests with diverse, more resilient trees;
- Using fertilization and land reclamation to promote forest growth.

Construction and infrastructure planning

- Sewage system maintenance and upgrade to required level;
- Employing green infrastructure to manage wet weather and flood impacts in the cities;
- Natural building shading solutions to reduce cost of cooling device installation and maintenance;
- Maintaining power lines, ensuring alternative supply;
- Improving pavement quality to prevent road deterioration;
- Using thicker drainage layer, culverts, planning roads on higher surfaces.

Civil protection and emergency assistance planning

- Creating unified catastrophe loss database;
- Developing early warning system;
- Improving monitoring and prediction systems;
- Raising population awareness;
- Adapting legislative changes.

Summary of adaption activities in Valka municipality

The following climate change risks have been discussed and evaluated as the main priority risks for Valka municipality. Experts were asked to use two main criteria to assess the risks - what is the impact of each of the identified risks to Valka district and what impact can be made to mitigate those risks at Valka district level, implementing various measures.

Five risks were prioritized:

Healthcare/public health:

- Chronic diseases flare (CVD, diabetes etc.) and increase in death rate
- Acquired endemic state and/or increase in diseases caused by insect-born infections

Construction and infrastructure planning

- Increase storm-caused rooftop damage
- Electrical transmission network damage due to wind gusts
- Road damage risk due to rainfall caused flooding

During the meeting on 8 September 2017 these risks were discussed and the following adaptation activities were mentioned:

Local experts pointed out that the main activities that could be implemented for healthcare and welfare are:

1. Informative seminars
2. Raising awareness
3. Educating medical personnel and social workers.

For construction and infrastructure planning:

4. Sewage system maintenance and upgrade to required level - in the case of heavy rainfall, it's not sufficient to pump large volumes of water; an increase in capacity is required.
5. There is a need to develop technical guidance project to optimize rainwater drainage systems.
6. Inspection of canal locks on river Pedele (Selija street) to assess its operational state.
7. Maintaining power lines, ensuring alternative supply;
8. Tree removal around power lines to prevent wind-caused disruptions
9. Exploring alternative energy sources

In addition an activity was suggested for a risk that was not rated as priority, but is also significant:

10. Herd grazing in hogweed spread territories, mowing, chemical control (herbicides) to manage the generalist species spreading and replacing the specialist species

The identified adaption activities are partially in line with the national research, but in this case, the focus, of course is on those activities which can be carried out locally. For example, adjusting legislation or adapting the measurement, prediction or early warning system is also relevant, but taken into account the size of Latvia and Valka, these measures should be implemented in a national level.